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GLOBAL CHANGE AND THREATS TO COMMUNITIES: DISASTER MANAGEMENT

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ABSTRACT: Communities that range from very small to mega-cities have one common characteristic in that they are all vulnerable to natural hazards with the focus of this paper on weather-related hazards. A hazard can be defined as "a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation". There has been a dramatic increase in natural hazards throughout the globe over the past decades, dominated by the dramatic rise in disasters of hydrometeorological origin. There is a need to bring the focus of governments and people on reducing the impacts by investments in, among other things, infrastructure renewal and hazard warning systems. In Canada, that has not been the case as investment in public infrastructure decreased as a percentage of Gross Domestic Product (GDP) over the past few decades. Hazard forecasts and warnings can play a major role in prevention and hazard warning systems should become the keystone of governmental and international systems, both embedded in their emergency management system and their approaches to sustainable development. In considering global change, including climate change, and the threats to communities, it is important that there be a shift in the balance of emphasis and investments in disaster management between response-recovery and prevention (preparedness and mitigation). These do not mean failing to respond to disasters but making investments in prevention resulting in less need for expenditures in response-recovery. With the impacts of natural disasters, development cannot be sustainable. Societies need to look to the future and make investments now that will allow future generations to meet their needs consistent with those of present generations. Natural disasters and climate change are part of that future and must be considered to make sustainable development a possibility.

Keywords: global change, communities, natural hazards, disasters

1. Introduction

Communities range from very small to mega-cities but they all have at least one common characteristic; they are all vulnerable to natural hazards. Structures, transportation and telecommunications systems and, most importantly, people are all impacted by natural hazards, such as wind, rain and earthquakes. The focus of this paper is on weather-related hazards that occur on time scales of the present to decades – each bringing a set of hazards. And their effects have been witnessed.

In 2004, Florida was impacted by an unprecedented four hurricanes hitting the state in one season. Earlier that same year, Catarina was the first hurricane recorded in the South Atlantic when it was spotted off the coast of Southern Brazil. When Hurricane Juan hit the Canadian province of Nova Scotia on 29 September 2003, it was the strongest hurricane for the region in over 100 years with maximum sustained wind speed of 160 kilometres per hour and gusts of up to 230 kilometres per hour. Waves in excess of 20 metres occurred and there was much erosion, particularly in the Bedford Basin. There was widespread damage in central Nova Scotia and Prince Edward Island and at least 8 human lives were lost. More than 300,000 people were without power for up to a week and a half (McBean, 2005). In 2003, there were also floods in the Canadian provinces of Newfoundland, Quebec, British Columbia and Alberta and major wildfires, especially in the interior of British Columbia. In August, a power outage left most of the Canadian province of Ontario in the dark, creating considerable chaos. The trigger event was not a weather event, as first reported, but it could have been. Other recent Canadian natural disasters have been Saguenay flood of 1996, the Red River flood of 1998 and the 1998 Eastern Canada ice storm. The ice storm was responsible for at least 28 human deaths, over 900 human injuries and near CAN$7 billion in damages (Public Safety and Emergency Preparedness Canada, 2005). On August 19, 2005, a single rain-wind event near Toronto cost the Canadian insurance industry over CAN$400 million in costs for damages.

Around the world, the economic costs of natural disasters are rising dramatically from an average annual amount over a 10 year period of US$4 billion per year in the 1950's, to US$13 billion per year in the 1970's, and to US$65 billion per year in the 1990's (MunichRe, 2005); and the first years of this decade indicate that the costs are continuing to escalate. Natural disasters in 2004 are currently estimated to have caused economic losses totalling US$140 billion (WCDR, 2005). Hurricanes Katrina and Wilma in 2005 are now the largest single events but more horrific ones are likely on the horizon (McBean, 2005). The costs in terms of impacts on humans are also rising. Worldwide during the 1990s, there were more than 2,500 natural disasters, resulting in more than 650,000 people killed and more than CAN$1 trillion in damage. These losses were 40-fold greater than during the 1950s (ICLR, 2005).

2. Natural Hazards

A hazard can be defined as "*a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation*" (UNISDR, 2005). It is important to note that the event is only potentially damaging. The magnitude of the impacts or damage depends on the vulnerability of the impacted system or population. Vulnerability can be defined as "*conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards*" (UNISDR, 2005). Disasters result when hazards and vulnerable systems intersect. Reducing disasters requires a multi-disciplinary approach to the study of both hazards and vulnerable systems. Although some disasters make the front pages of newspapers around the globe, most do not and their impacts are only recognized by the communities impacted. A disaster is defined as "*a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources*" (UNISDR, 2005) and the categorization of a disaster takes into account the ability of a community to cope on its own. Thus, disasters are very much defined in terms of the local community which reinforces the notion that the study of disasters requires a multi-disciplinary approach with the addition of a community focus. The community focus avoids arbitrary definitions of disasters in terms of financial loss, which would bias any tabulations to wealthier societies or lives lost, which would be a bias towards areas of higher population density.

Based on this definition, global statistics on the occurrence of disasters have been prepared. The number of disaster events has risen from 65 per year in the decade of 1960-69, to 280 per year in the 1980's, to 470 per year since the beginning of this century (EM-DAT, 2005) - a dramatic increase. Most of the disasters and the dominating factor in the increase is the dramatic rise in disasters of hydrometeorological origin. For the period 1994 to 2003, 33 percent of disasters were the result of floods, 23 percent from storms and 15 percent from droughts. Since most landslides and avalanches are of hydrometeorological origin, hydrometeorological events generated more than three-quarters of all disasters. Earthquakes and tsunamis created only 7 percent of events, but their impacts when they occur can be especially horrendous.

Natural and human events interact on time scales of the present to the next decades. Industrial and transportation processes lead to urban smog, affecting the health of citizens. The same sources are responsible for significant greenhouse gas emissions as well, leading to a changing climate with more hot days, which are conducive to more smog days.

3. Disaster Management

The United Nations International Strategy for Disaster Reduction (UNISDR, 2005) was created to follow and build upon the United Nations International Decade for Disaster Reduction (IDNDR). The UN ISDR has identified climate change as one of the issues related to disaster management. Disaster management refers to policies and practices developed and implemented to manage the impacts of disasters. Effective disaster management requires extensive planning before a disaster, targeted at four elements (Godschalk, 1991): preparedness (policies and procedures designed to facilitate effective response); response (actions taken immediately before, during and after a disaster to protect people and property and to enhance recovery); recovery (actions taken after a disaster to restore critical systems and return a community to pre-disaster conditions); and mitigation (actions taken before or after a disaster to reduce the impacts on people and property of future hazards). Mitigation, with its focus on preventing natural hazards from becoming natural disasters, includes policies and actions such as building public awareness and support; development of local and regional plans for land use to prevent inappropriate development in hazardous areas; changing building codes and standards to protect people, property and infrastructure from "reasonable" extremes; structural engineering to increase resistance; and forecasting and warning systems which provide information to citizens and advise them regarding an appropriate response strategy.

There is a need to bring the focus of governments and people on reducing the impacts by investments in, among other things, infrastructure renewal and hazard warning systems. In Canada, that has not been the case as investment in public infrastructure decreased as a percentage of Gross Domestic Product (GDP) from 4.5 to 5 percent in the 1960's to about 2.5 percent in the 1990's (ICLR, 2005). Further, in the 1990's, investments in the national weather service, the basis for a warning system, was reduced by over 35 percent (see Government of Canada, 1991 to 1999).

In considering disaster mitigation policy, the issue arises as to why do governments not invest in prevention-mitigation (Henstra and McBean, 2005)? One explanation is public apathy or inability to respond. The sense that natural hazards are acts of God and they will not strike twice may contribute to the reluctance to invest. This highlights the need for public education. Insurance can play a role both in reducing incentives to invest, since insurance will pay for costs if a disaster occurs, but also in encouraging investments through premium incentives. Scientific uncertainty may also play a role, since it can be used as a reason for inaction, although the precautionary principle in the Climate Change Convention states that "*where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing [precautionary] measures*" (UNFCCC, 2005). The benefits and costs of prevention/mitigation need to be further analyzed although most analysis shows that it is cost effective (Mileti, 1999). An important issue is that the costs come now while the benefits come later. Further, in most countries, there is a division of responsibilities such that investments in mitigation are usually required from the local government while the costs of recovery are from a more senior level of government. This makes a mismatch in credits and debits which affects the politics of decision making. Although *"(t)here is no role more fundamental for government than the protection of its citizens"* (Government of Canada, 2004), government choices as to where to make investments are often driven by the short-term, potential political benefits towards re-election.

4. Increasing trends

Why have there been these increases in the numbers and costs of natural disasters? Global human population has been increasing and there has generally been more exposure of people to hazards with more people and communities at risk. People are also living by choice or circumstances in more hazardous zones - along coasts, riverbanks and mountain slopes. There has also been a growing inequality between poorer and wealthier sectors of society and the poorer sectors are more vulnerable. There is more expensive infrastructure being damaged. In urban regions (and particularly in very large cities), the complex infrastructural systems that make life and economic activity possible increase the vulnerability of populations to disruptions caused by natural hazards. The density of buildings has been growing, and with investments in infrastructure renewal declining, the average age is

increasing. Commercial activities have become more interdependent and vulnerable, including relying more on the transportation of people and goods. Human interventions in the environment can also increase vulnerability to natural hazards. Changes in land cover can increase risks of landslides or flooding and destruction of coastal mangrove areas can increase the susceptibility of coastal areas to storm surges and tsunamis. Changing weather conditions also play a significant role. Climate change adds to the risk, and the climate will be changing, at least for the next century (IPCC, 2001), while countries take emission reduction actions.

A recent statement issued by the international science academies summarizes the issue of climate change and its significance for the global community. The statement, titled *Global Response to Climate Change* (UK Royal Society, 2005) and signed by the presidents of the academies of science of all G8 countries, as well as by those of China, India and Brazil, states that "*climate change is real*" and that actions must be taken to "*reduce the causes* [and] *prepare for the consequences of climate change*". In other words, nations must work together to stabilize the amount of greenhouse gases in the atmosphere in order to mitigate climate change, all the while adapting to what will inevitably be a changing climate. The Gleneagles G8 Summit communiqué of 2005 stated "*Climate change is a serious and long-term challenge that has the potential to affect every part of the globe*" (G8, 2005). More recently, the Intergovernmental Panel on Climate Change (IPCC, 2007) stated that "*Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Eleven of the last twelve years (1995 - 2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850).*" The IPCC goes on to say that "*Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.*"

For the next two decades, there will be a warming of 0.2 degrees Celsius per decade and after that the effects of whatever emission reduction strategies that countries adopt will start to have an effect. By the end of the century, global warming will likely range between 1.1 degrees Celsius and 6.4 degrees Celsius depending on the emission scenario.

Although the earlier quote about *"the protection of its citizens"* was actually in the context of terrorism, then Canadian Environment Minister David Anderson (CNN, 2004) stated that "*Global warming poses a greater long-term threat to humanity than terrorism.*" Climate change is expected to change our physical environment in a number of ways, including more frequent and intense hazardous events, sea level rise and various impacts related to changing temperatures. "*The vulnerability of human societies and natural systems to climate extremes is demonstrated by the damage, hardship, and death caused by events such as droughts, floods, heat waves, avalanches, and windstorms. While there are uncertainties attached to estimates of such changes, some extreme events are projected to increase in frequency and/or severity during the 21st century due to changes in the mean and/or variability of climate, so it can be expected that the severity of their impacts will also increase in concert with global warming"* (IPCC, 2001).

The Intergovernmental Panel on Climate Change projects that climate change will accelerate in the decades to come, leading to changes in the frequency of extreme natural events. The latest Summary for Policy Makers (IPCC, 2007) concluded that it is very likely there will be increases in frequency of warm spells or heat waves over most land areas. The heat wave in Europe in August 2003 resulted in almost 15,000 human deaths in France and a total of more than 35,000 across Europe. This would foretell the probability of increased mortality in old people in urban areas. The frequency of heavy precipitation events (or the proportion of total rainfall from heavy falls) is very likely to increase over most areas. This would lead to floods, land slides and mudslides with impacts on people and communities. Likely increases in drought frequency will impact on drinking water, agricultural productivity, hydropower and the risk of wildfires. It is also likely that intense tropical cyclone activity will increase with major impacts. In light of these future projections and already-observed increases in costs related to weather-climate hazards, policies and programs are necessary to both mitigate climate change (for example, through emissions reductions) and to adapt to the inevitable effects of a changing climate. Sea level rise will amplify the threats due to storm surges and coastal flooding. According to the Second World Climate Conference (1990), "It (climate change) could even threaten survival in small island States and in low-lying coastal, arid and semi-arid areas."

5. Hazard warning systems and the vulnerability of communities

Prevention, mitigation plus some aspects of preparedness, includes anticipating the hazards through forecasts and warnings, that is, advising people about impending events and providing advice on appropriate response strategies. For example, for a tornado, the warning time is only 10's of minutes so the response is to take shelter. However, if the forecast is for a river flood cresting in the next few days, people can prepare for evacuation and implement emergency responses such as sandbagging homes and buildings. Forecasts of changing conditions over seasons to decades need to be factored into mitigation approaches. Hazard forecasts and warnings can play a major role in prevention and hazard warning systems should become the keystone of governmental and international systems, both embedded in their emergency management system and their approaches to sustainable development (McBean, 2007). Predictions need to be seen in the context of this continuum of time, each with appropriate policy responses.

An important part of any warning system is a public education program and a communication strategy that enables the messages to be delivered to people. A warning that is not heard, or, if heard, not appropriately acted upon, does not save lives and reduce damage and is a waste of resources. Public education is needed to advise people of how and when to respond to messages of impending events. People need to be advised on the appropriate actions. Communication systems need to be in place to warn people. These should be tailored to the local population and learn from examination of what works.

Disaster management has traditionally included both structural and non-structural approaches. Structural approaches include making structures (dykes, levees, buildings, power lines, etc.) more resistant to natural hazards. This is accomplished by governments in part through building codes. Loss of electricity during a natural hazard is one of the major concerns and the practice has been to build transmission towers to withstand strong loads of wind or ice. Unfortunately, some natural hazard will eventually occur that exceeds the design specifications and it will break, often catastrophically. Newer approaches now include the concept of resilience, so that transmission towers are built with break away arms, so that they can more easily be rebuilt when failure occurs, reducing the time before power is re-

established. In taking actions to reduce the vulnerability of cities, governments should look at the approach embodied in the ideas of resilient communities (McBean and Henstra, 2004). Non-structural approaches to disaster management and responding to climate change include better land-use planning, using insurance (especially to create incentives) and educational programs to have a better informed population.

The vulnerability of communities will increase due to risks from weather-related events. The design criteria for new infrastructure and urban design need to be based on the best estimates of future conditions, not on the past climate. Although the weight of scientific evidence, as discussed above, is that the climate is changing, it also needs to be noted that the Precautionary Principle, as noted above, was adopted by nations as Principle 15 of the "1992 Rio Declaration on Environment and Development" and reaffirmed at the World Summit for Sustainable Development, in Johannesburg in 2002, and also included in the UN Framework Convention on Climate Change (2005).

6. Policy Issues for Governments – disaster management, climate change, international development

Among the many policy issues upon which governments must make decisions and investment are disaster management, climate change and international development. Unfortunately, in most countries these are dealt with separately with disaster management the responsibility of a ministry of public safety (which is now mostly taken up with anti-terrorism issues), climate change assigned to the environment ministry and international development linked with foreign affairs and/or international trade. There is a need for intersections on these policy issues – a reality that has been recognized internationally.

The Objective (Article 2) of the United Nations Framework Convention on Climate Change, which has been signed and ratified by almost every country in the world, is "*…stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic [human-induced] interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to*

enable economic development to proceed in a sustainable manner" (UNFCCC, 2005). The connections between climate change and development and food production are explicit in this objective.

Since vulnerability to climate change and weather events is determined by physical, social, economic, and environmental factors of the community, impacts on people are linked to development. This is demonstrated by statistics on disaster-related- deaths per year per million of human population. When the Development Index is high, the number is 0.4; when it is medium, the death ratio increases to 10 and it exceeds 40 for countries with low Development Indices (Mutter, 2005). Another similar statistic is the number of deaths per disaster which increases from 22 human deaths per disaster in highly developed countries to 145 in medium and over 1000 in least developed countries (WCDR, 2005). While the costs for events in developed countries typically are very large, they are not as large as some events, as a percentage of Gross Domestic Production (GDP), in developing countries. For example, while hurricanes in the USA are typically less than 1 percent of the national GDP, the 1999 earthquake in Turkey was a cost of about 8 percent of GDP and the 1998 hurricane in Honduras cost about 75 percent of its GDP (Handmer, 2003). Major disasters have set the development of countries back years, if not decades.

The World Summit for Sustainable Development (WSSD), in 2002 in Johannesburg, adopted a Summit Plan of Implementation (WSSD, 2002) as part of the strategy to meet the Millennium Development Goals (MDG, 2000). In the report which followed the Summit, strong connections were drawn between achievement of the MDG and international development and natural hazards and climate change. Actions were called for, including:

- *"37. An integrated, multi-hazard, inclusive approach to address vulnerability, risk assessment and disaster management, including prevention, mitigation, preparedness, response and recovery, is an essential element of a safer world in the twenty-first century. Actions are required at all levels to:*
  (a) Strengthen the role of the International Strategy for Disaster Reduction and encourage the international community to provide the necessary financial resources to its Trust Fund;
  (e) Improve techniques and methodologies for assessing the effects of climate change, and encourage the continuing assessment of those adverse effects by the Intergovernmental Panel on Climate Change;

(h) Develop and strengthen early warning systems and information networks in disaster management, consistent with the International Strategy for Disaster Reduction;

(j) Promote cooperation for the prevention and mitigation of, preparedness for, response to and recovery from major technological and other disasters with an adverse impact on the environment in order to enhance the capabilities of affected countries to cope with such situations.

- *38. Change in the Earth's climate and its adverse affects are a common concern of humankind. We remain deeply concerned that all countries, particularly developing countries, including the least developed countries and small island developing States, face increased risks of negative impacts of climate change and recognize that, in this context, the problems of poverty, land degradation, access to water and food and human health remain at the centre of global attention. …. Actions at all levels are required to:*

  (a) Meet all the commitments and obligations under the United Nations Framework Convention on Climate Change..."

Both the Millennium Summit Declaration and the World Summit report demonstrate explicit connections between natural hazards, climate change and the Millennium Development Goals.

The participants at the 2005 World Conference on Disaster Reduction agreed to the following declaration:

- *"1. We will build upon relevant international commitments and frameworks, as well as internationally agreed development goals, including those contained in the Millennium Declaration, to strengthen global disaster reduction activities for the twenty-first century. Disasters have a tremendous detrimental impact on efforts at all levels to eradicate global poverty; the impact of disasters remains a significant challenge to sustainable development.*
- *2. We recognize the intrinsic relationship between disaster reduction, sustainable development and poverty eradication, among others, and the importance of involving all stakeholders…"*

Again, an explicit link is drawn between the disaster reduction and the achievement of international development goals.

7. Responding to climate change and changing natural hazards

As noted above, nations must work together to stabilize the amount of greenhouse gases in the atmosphere in order to mitigate climate change, while adapting to what will inevitably be a changing climate. Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts and involves efforts to both reduce the negative impacts of climate change and to capitalize on its benefits (IPCC, 2001). Many features of climate change important for changing vulnerability and requiring adaptation are those related to climate-weather extremes (Burton *et al,* 2002). In many countries, the focus has been on meeting the emissions reduction targets with relatively little emphasis on adaptation. The balance of expenditure between adaptation and mitigation needs to be addressed.

Adaptive capacity or the "*adaptability of an affected system, region, or community to cope with the impacts and risks of climate change*" (IPCC, 2001) is determined by local or regional socioeconomic conditions. Enhancing adaptive capacity and providing better means to cope can simultaneously address issues of climate change and natural hazards while contributing to development. This is the natural means of connecting these intersecting issues. Adapting to climate change and mitigation strategies for natural hazards are essentially the same in concept and approach and they both link to sustaining development.

A government's adaptation strategy needs to be built across government and not reside solely within one agency. Ministries of transportation, infrastructure and communities, public safety and international development all need to be part of this undertaking. In essence, an adaptation strategy for climate change overlaps strongly with a mitigation strategy for natural hazards. It is unfortunate that the two communities have been isolated so much that the term mitigation means different things to the two communities.

Since vulnerability to disasters and climate change is a function of human actions and behaviour, it is determined by several factors, including awareness of hazards and climate change impacts, condition of human settlements and infrastructure, public policy and administration, the wealth of a given society and organized abilities in all fields of risk management. Specific dimensions of social, economic and political vulnerability include inequalities, gender relations, economic patterns, and ethnical or racial

divisions. It is clear that reducing vulnerability requires a multidisciplinary approach with strong inputs from the social science. The vulnerability of new developments will depend in part on how well they take into account the susceptibility to natural hazards or a changing climate.

The International Council for Science (ICSU, 2005) has established an International Planning Group to prepare a scientific rationale and plan for a research programme on Natural and Human-induced Environmental Hazards and Disasters, chaired by this author. The 28th ICSU General Assembly (ICSU, 2005) recommended:

- "*a programme of research aimed at strengthening international science to provide a firmer basis for policies to prevent natural hazards from becoming disasters. Such an objective will need:*
  - *an international collaborative research programme lasting a decade or more*
  - *the combined insights of the natural, health, social and engineering sciences*
  - *engagement with populations living in hazardous areas, to understand better the social and cultural determinants of choice in the hazards context*
  - *engagement with policy-makers at regional, national and international level, to understand better the constraints on policy-making in the hazards context*
  - *the ability to accommodate both individual hazards and the interplay between hazards*
  - *a long-term perspective*
  - *a focus on delivering new scientific insights for the primary customers development agencies, humanitarian assistance agencies and governmental policy-makers.*
- *This is an ambitious undertaking, in keeping with the importance and complexity of the subject. ICSU will need to work with appropriate partners to achieve its goals.*"

The research program will consider natural and human-induced environmental with the span of hydrometeorological and geophysical trigger events and related events, including fires, locusts and the impacts of land-use practices and human activities. The research focus will be on mitigation-prevention and preparedness with the objective of undertaking coordinated

international multi-disciplinary research leading to more effective global societal responses to the risks of hazards. The legacy of the Program will be an enhanced capacity around the world to address hazards and make informed decisions on actions to reduce their impacts. Hopefully, in ten years, the result will be that, when comparable events occur, there is a reduction in relative loss of life, and fewer adversely impacted and wiser investments and choices are made by civil society.

8. Summary and conclusions

In considering global change, including climate change, and the threats to communities, it is important that there be a shift in the balance of emphasis and investments in disaster management between response-recovery and prevention (preparedness and mitigation). These do not mean failing to respond to disasters but making investments in prevention resulting in less need for expenditures in response-recovery. Within their climate change policies, governments also need to recognize and inform their populations that the climate change issue is multi-decadal and that climate is already changing and will continue to change as emissions reduction strategies start to make a difference. In that context, there is a need for an adaptation strategy to reduce impacts and gain benefits. These prevention and adaptation strategies need to be strongly linked and integrated across governments' files. These strategies can be developed within the framework of sustainable development, that "*Humanity has the ability to make development sustainable - to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987). With the impacts of natural disasters, development cannot be sustainable (Mirza, 2003). Societies need to look to the future and make investments now that will allow future generations to meet their needs consistent with those of present generations. Natural disasters and climate change (Beg *et al.*, 2002) are part of that future and must be considered to make sustainable development a possibility.

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